New

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Noise Cancellation Products

bhi DSP Noise Cancellation Products for Radio and Voice Communications

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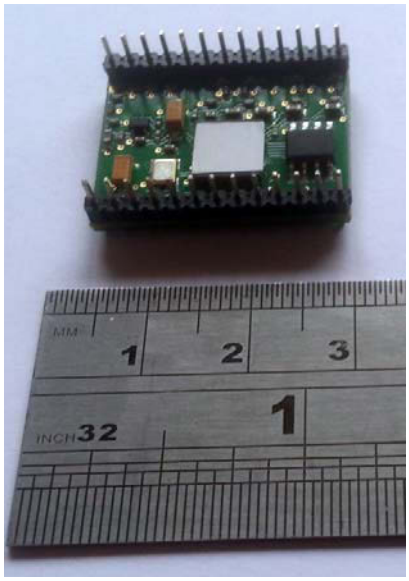


NEDSP900

Preliminary Datasheet/User Manual

Main Features:

- Dual channel configurable Noise Suppression
- 30 dB AGC in channel 1 switchable
- Up to 30 dB maximum gain configurable input amplifiers
- Low power consumption (typ <5mA)
- Wide supply voltage range (3 to 20V)
- In-and outputs RF protected with LC low pass filter
- Up to 40dB noise suppression
- Audio bandwidth 300Hz to 5KHz

Applications:

- Noise Cancelling Microphones
- Noise Suppression for radio voice communications
- Noise Cancelling in voice recognition to improve accuracy rates
- Intercoms

1. Introduction

The **NEDSP900** is a dual channel audio Noise Suppression pcb module capable of handling a wide range of audio inputs and providing up to 40dB of noise suppression.
The module operates on a single supply rain with on-board voltage regulation and clock oscillator. It has low power consumption which makes it suitable for portable applications.

The noise suppression is carried out using a Digital Signal Processing (DSP) device that runs software containing a **CNS Noise Suppression** algorithm**.** This is patented technology for noise reduction of speech signals. It is known as one of the best algorithms of its kind and is ideally suited for real-time processing in any kind of voice communication system in noisy environments, such as handsfree telephone sets, industrial intercom systems and radio communication systems.

2. Module Outline

The module comprises a multi-layer PCB that provides good signal isolation and grounding making integration into target systems easy with the minimum of design effort. A few simple rules need to be observed in order to preserve the achievable levels of noise suppression, these are dealt with later in this document. Pins are on a 2mm pitch.

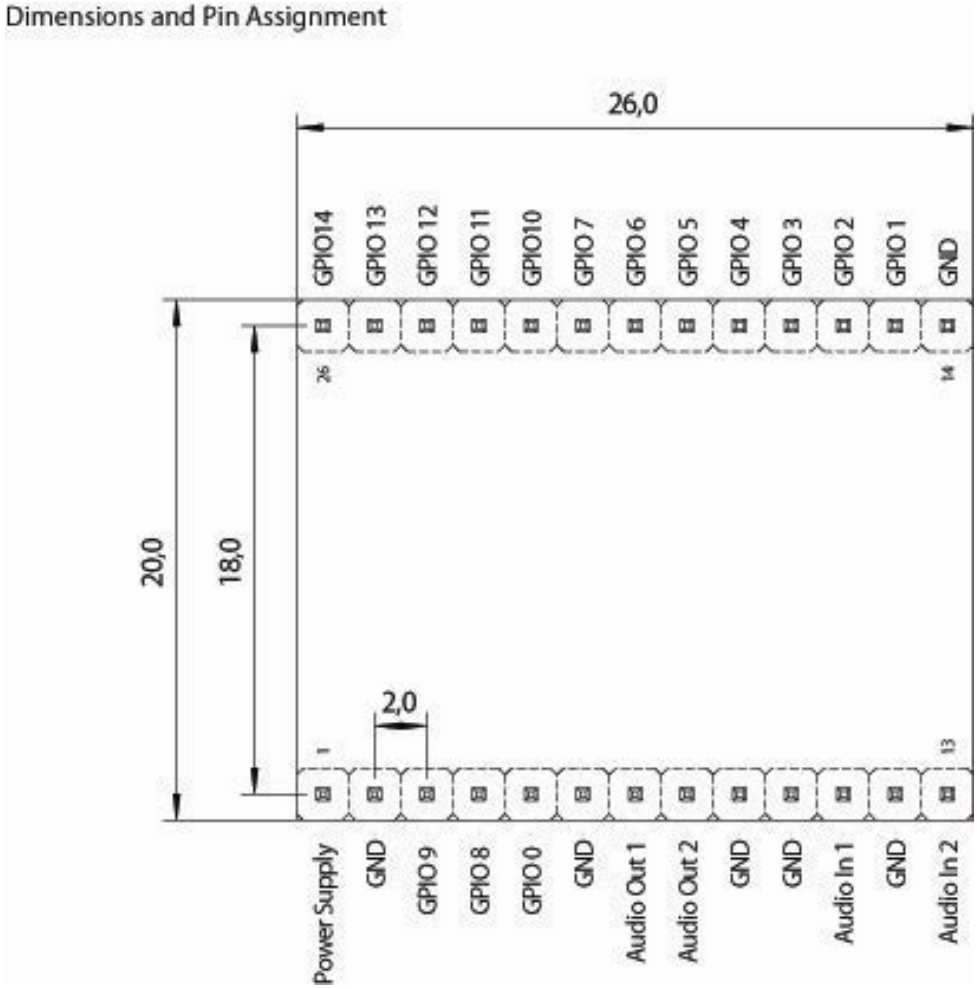


Fig 1: View looking down on top of module showing basic dimensions and pin designations

3. **Pin Designations** (see fig1)

From the annotated module outline fig1 on the previous page, the pattern of the pin-outs provides the user with good signal separation that can be continued easily on any board designed to carry the analogue and digital interface electronics.

Pin	Designation	Function	Use
1	+ve Supply	Positive supply input	+5V to +20V supply
2	GND	Ground - Power	Associated with Supply
3	Cnl 1 NS On/Off	Channel 1 Noise Suppression On/Off	Internal Pull Up
4	Cnl 1 NSL Bit 2	Channel 1 Noise Suppression Level control Bit 2	Internal Pull Up
5	Cnl 1 Gain Bit 0	Channel 1 Input Gain control Bit 0	Internal Pull Up
6	GND	Ground –use for Analogue/Digital Isolation	
7	Audio 1 Out	Channel 1 Audio Output	DC Isolated
8	Audio 2 Out	Channel 2 Audio Output	DC Isolated
9	GND	Ground – for use with Audio I/O Isolation	
10	GND	Ground – for use with Audio I/O Isolation	
11	Audio 1 In	Channel 1 Audio Input	DC Isolated
12	GND	Ground – for use with Audio Inputs	
13	Audio 2 In	Channel 2 Audio Input	DC Isolated
14	GND	Ground associated with Control Signals	
15	Cnl 1 Gain Bit 1	Channel 1 Input Gain control Bit 1	Internal Pull Up
16	Cnl 1 Gain Bit 2	Channel 1 Input Gain control Bit 2	Internal Pull Up
17	Cnl 2 Gain Bit 0	Channel 2 Input Gain control Bit 0	Internal Pull Up
18	Cnl 2 Gain Bit 1	Channel 2 Input Gain control Bit 1	Internal Pull Up
19	S.F.	Special Function – Algorithm ‘Hold/Run’	Leave open*
20	Cnl 1 NSL Bit 0	Channel 1 Noise Suppression Level control Bit 0	Internal Pull Up
21	Cnl 1 NSL Bit 1	Channel 1 Noise Suppression Level control Bit 1	Internal Pull Up
22	Cnl 2 NSL Bit 0	Channel 2 Noise Suppression Level control Bit 0	Internal Pull Up
23	Cnl 2 NSL Bit 1	Channel 2 Noise Suppression Level control Bit 1	Internal Pull Up
24	Cnl 2 NSL Bit 2	Channel 2 Noise Suppression Level control Bit 2	Internal Pull Up
25	Cnl 2 NS On/Off	Channel 2 Noise Suppression On/Off	Internal Pull Up
26	Cnl 1 AGC On/Off	Channel 1 Automatic Gain Control On/Off	Internal Pull Up

***- S.F . Pin 19. – Leave this pin un-connected. See para 14.**

4. Power Supply

Pin 1 (+Ve Supply) is the device power pin. The module has an ‘on-board’ regulator providing the internal circuits with a regulated supply. The regulator requires a minimum of +3V to provide good regulation and can handle up to +20 Volts Maximum. Due to size constraints the module is not fitted with reverse voltage protection or current limiting circuitry, therefore it is recommended that connections are checked well before applying power to the module.

The module takes approximately 7mA when fully operational.

It is recommended that, if the module is to be used with other interface circuitry be it buffering the analogue or digital signals, that further local supply suppression is used between Pins 1 and the nearest ground (Pin 2 is ground). This should be carried out in line with common engineering practices. A set of values of 10uF (Tantalum or Low ESR electrolytic), 100nF Ceramic and 10nF Ceramic should be considered.

If it is expected that the Power Supply are to be very noisy, then consider fitting a 'Pi' filter network close to Pins 1 and 2. Again this is a common practice.

5. Audio

All audio Inputs and Outputs have Radio Frequency (RF) filters to minimise the risk of EMC problems when used in high – RF Environments such as communication systems.

Dependant on the modules use, the audio signals may be at very different levels, this is very likely to be the case between the Audio Inputs and Outputs, but also may be the case between the two audio channel inputs (if for instance a microphone is being used on Channel 1 and a Line level is being used on channel 2). Minimise the possible cross-talk between all the channels in line with common audio practices.

6. Digital

The digital control pins are all pulled up internally (via several hundreds of kilo-Ohms). In operation the pins are normally pulled down to ground. Pins or functions that are not used can be left with the appropriate pin 'floating'. However, in applications where external interfacing is being used or the electrical environment is noisy, the pins may be pulled up, using a much lower resistance (say a few 10's of kilo-Ohms) to a supply of no more than 1.8 Volts referenced to ground.

Functionality

The following sections deals with the basic device functionality and what settings can be made.

7. Audio Gain

The two audio channels are independent and have individual input gain setting facilities.

Channel 1 is recommended for Microphone signals as this has up to 30dB of selectable gain and a unique AGC control. Channel 2 has its gain limited to +18dB. This makes the module useful for many applications that involve processing either Stereo Audio signals or two different Audio signals such as Microphone signal and a Receiver audio signal (as would be found in a communication or Intercom system).

Note:

Two important things to note about the audio channels, firstly the Gain setting only takes place when the module initialises. This means that any change in audio Gain setting can only be done before powering the module. Secondly, due to the design of the DSP device silicon, at 0dB audio gain selection, there may be up to 9dB of insertion loss between the module input and output.

8. Channel 1 Gain

Gain (dB)	Module Pin 16/ Gain Bit 2	Module Pin 15 Gain Bit 1	Module Pin 5 Gain Bit 0
0	1	1	1
12	1	1	0
15	1	0	1
18	1	0	0
21	0	1	1
24	0	1	0
27	0	0	1
30	0	0	0

Note: '1' is pin left open or pulled up to 1.8V, '0' is pin pulled to ground.

9. Automatic Gain Control (AGC)

Like the other control pins, pin 26 (Cnl 1 AGC On/Off) requires pulling to ground to invoke the AGC action on. Leaving this pin unconnected or high will inhibit the AGC action.

Note: The AGC control pin does not require the module to be re-powered to take effect.
The AGC action makes use of the full 30dB Gain range and as such inhibits any pre-set gain. When operating it keeps the audio output level within 10dB of the maximum module output level, no matter how much the input level is varying.

The AGC has a unique action, in that it recognises speech in a similar way to that of the Noise cancellation programme. If there is no speech present, the AGC tends to hold the audio gain until it next recognises a speech pattern. This holding of the Gain setting means that the audio does not suddenly increase or start to 'breath' when the speech disappears. Any small amount of recognisable speech will start the AGC tracking again.

10. Channel 2 Gain

This channel has less gain and therefore unsuitable for direct connection to a microphone, however, it does still have sufficient gain to be used with many low level output devices such as receiver detectors.

The gain settings for Channel 2 are as follows:

Gain (dB)	Module Pin 18 Bit 1	Module Pin 17 Bit 0
0	1	1
12	1	0
15	0	1
18	0	0

Note: '1' is pin left open or pulled up to 1.8V, '0' is pin pulled to ground.

11. Channel Overloading

The module handles large input signals quite well. However, the user should try and keep their maximum input levels below 1 Volt peak to peak (with gains set to 0dB). Above this value, a set of protection diodes will act and the audio will sound distorted, however it will still continue to operate.

Unfortunately, there are no overload indications available from the module and it is left up to the user to ensure that the maximum module limits are adhered to or an overload detector is provided to warn of such situations.

12. Noise Suppression

The noise suppression of each channel may be selected independently.

There are 8 levels of noise suppression per channel plus each channel may have its noise suppression switched off.

Channel 1	Module Pin 4	Module Pin 21	Module Pin 20
Channel 2	Module Pin 24	Module Pin 23	Module Pin 22
	Bit 2	Bit 1	Bit 0
Attenuation (of white noise - dB)			
8	1	1	1
12	1	1	0
16	1	0	1
20	1	0	0
25	0	1	1
30	0	1	0
35	0	0	1
40	0	0	0

13. Noise suppression ON/OFF

The noise suppression function may be switched off on either channel. This is accomplished using Pin's 3 for channel 1 and Pin 25 for channel 2. Like the other control pins, to invoke noise

suppression on the channel take the appropriate pin down to ground. Allowing the pin to float will inhibit the noise suppression.

14. S.F. - Pin 19 (Special Function)

The Noise Cancellation programme has a special function built in to allow it to be used in PTT intercom systems. This special function pin enables the noise cancellation to held at the current value. When the pin is released (allowed to float to 1.8 Volts), the algorithm continues where it left off. This is very useful when the module is used in a half duplex intercom system. More information available on request.

15. Electrical Characteristics

Absolute Maximum Ratings:
Power Supply Voltage: +24V; Negative voltage is not allowed
Maximum voltage at Digital Inputs: > -0.2; <1.8V
Maximum Voltage at Analogue outputs >0v; <2V
Maximum Ambient temperature: -50˚C to +100˚C
Storage Temperature: -55˚C to +150˚C
Operating Ratings: -40˚C to +85˚C

Parameter:	Symbol	Value	Remarks
Supply Voltage	Vs	3 to 20 Volts	
Power consumption	I	Approx. 7 mA	During operation of noise cancellation
Audio Channels		2	
Sampling Rate		16KHz	
Audio Bandwidth		300Hz to 5KHz	
Input:			
Input Level (Max.)	Vin	700mV (eff)	At 0dB input gain setting
Input Resistance	Rin	550kΩ	
Output:			
Output Level	Vout	220mV (eff)	
Output Impedance	Rout	12kΩ	
Signal to Noise Ratio	SNR	>60dB	20Hz to 20kHz; Measured at max. Amplitude
Total Harmonic Distortion (THD)	k	0.4%	Measured at 70% of max. amplitude
Crosstalk between output channels		>55dB	Measured at maximum amplitude
Power supply rejection Ratio		>70dB	At Vs=5V; 1V ripple 20Hz to 20KHz
Input to output latency		25mS	

16. Background information on the DSP Noise Cancelling

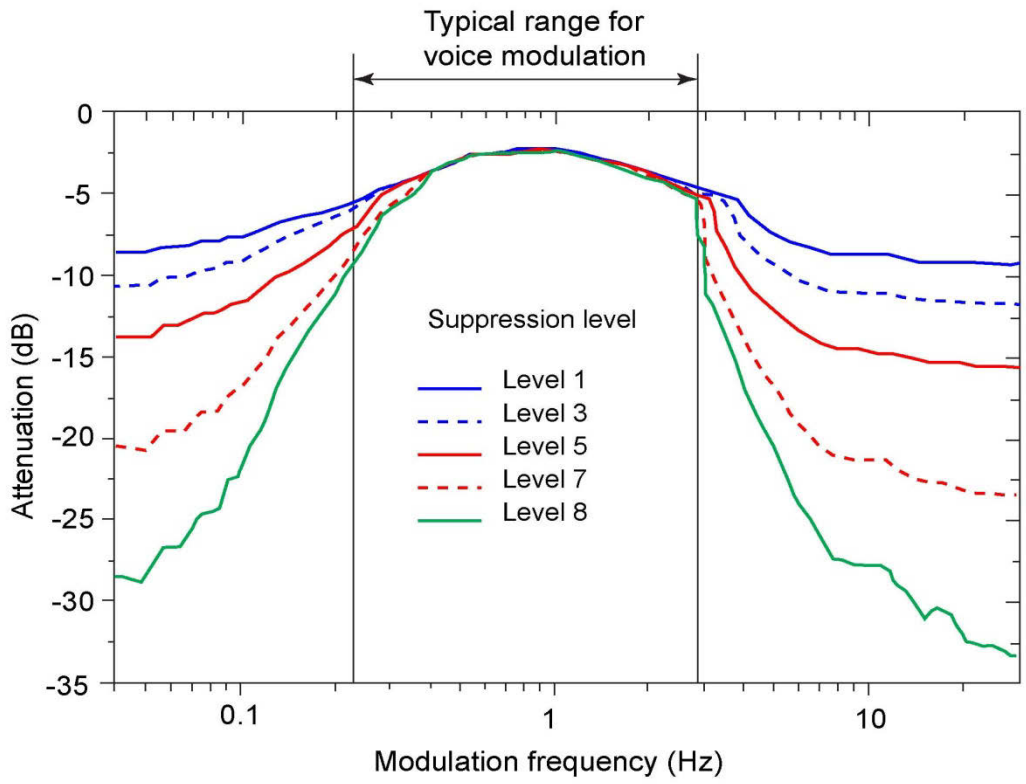
Automatic Gain control

Automatic Gain control (AGC) selects the optimal input gain according to the input level. For low input signals the AGC Increases the gain up to 30dB, whereas the AGC only cares for the voice content. The noise floor during speech pauses is disregarded due to the algorithm only looking for speech patterns.

CNS Noise Suppression

The CNS Noise suppression is capable of distinguishing between voice and noise components of an audio signal. One of the signal properties being monitored is the modulation frequency of each spectral component of the input signal.

Analysis of human speech yields typical modulation frequencies in the range of 2Hz to 5Hz. The idea of the noise cancellation algorithm is that the signal components that switch modulation frequencies in said interval, pass the system nearly without attenuation, while signal components with higher or lower modulation frequencies as classified as noise. Such components are attenuated independency of a selectable parameter. Figure 1 shows the modulation characteristic of the system measured with amplitude modulated white noise, shown for 3 different values of the Noise Suppression parameter.



17. Applications

The following section deals with the basic common practice requirements for integrating the **NEDSP900** module into a system.

A. Layout considerations

The NEDSP900 board is designed to provide a plug-in solution for noise cancellation. The board itself is designed to provide the best immunity from electrical noise and the best inter channel isolation, while giving the user plenty of latitude in way to incorporate the board into their system.

It's recommended that a good quality double sided PCB is used for the layout with good grounding throughout any circuitry preceding or following the module. Any ground areas should be solidly connected with all others to ensure good grounding system.

As previously stated, while the power pin is decoupled within the module, it is recommended that further decoupling is employed between pins 1 and 2 of the module. A set of parallel capacitors with values 10uF, 100nF and 10nF should be employed. If the supply rail is to be used for other circuits, further decoupling capacitors of appropriate values should be employed locally at these circuits as well.

In particularly noisy supply systems, use of individual 'Pi' filtering on the power supply lines should also be considered to de-couple the more sensitive devices.

B. Audio Lines

When placing audio tracks to and from the module pins, try to make as much use of the way in which the ground pins are provided to ensure isolation between the audio signals and the digital control signals.

Connecting Microphones

Only channel 1 (Pin 11 Signal /Pin 10 or 12 Ground) supports very low level inputs such as those provided by microphones. Almost any type of microphone may be used including low impedance (Circa. 300R or less) magnetic devices or higher impedance (1k0 or more) Electret inserts.

In the case of magnetic microphones, many of these have very low output levels of between 2mV and 5mV. With these signal levels you will probably need the highest gain available on audio channel 1. This will require all the 'Chl1 gain' pins to be grounded to provide the 30dB of gain.

In the case of Electret microphones, these can produce up to 20mV and therefore lower gains may be selected such as 21dB through to 27dB. Note that the module does not provide a bias voltage for electret microphones and this will have to be provided as part of the circuit into which the module is to be integrated. The manufacturer of the Electret module will usually provide the appropriate bias requirements and how to meet them. The **NEDSP900** audio input is DC isolated already, alleviating the need for extra DC Isolation capacitors being required between the microphone output and the module.

When using microphones for close in operation i.e. headset systems or desk microphones, it may be worth trying the modules AGC option – see section 9.0 of this manual.

Higher level input signals

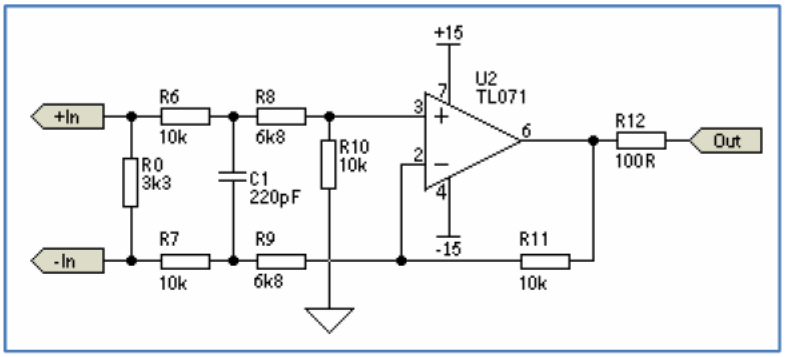
Because the **NEDSP900** has a wide range of gain settings, it is configurable for many types of input signal levels, however, if the module is to be used with speaker or headset output levels for instance an MP3 player or a mobile radio set, consideration should be given to the use of a potential divider network. The use of such a network will allow the system supplying the signal to be correctly loaded and for the signal to be reduced to adequate levels required for the **NEDSP900** input. Note that at 0dB gain setting on either audio channel the maximum input signal level is approximately 900mV p-p.

Audio Output

The **NEDSP900** has an output impedance of around 12KOhms, therefore if the maximum output level (approx. 500mV p-p) is too much for the following circuitry, then a 10 KOhm or 20 KOhm trimmer or volume control may be used to adjust the signal to attain the correct level. Do not use any resistance values of less than 10K Ohm as this may cause damage to the output circuitry.

Using with Balanced Audio

The module has an unbalanced signal input and output. This may be a problem for some that have balanced audio inputs or feeds that need to be balanced.



Input

If the input signal level and impedance allows, the simplest option is to use a balanced audio transformer. Apart from producing the balanced to unbalanced input transformation, the transformer also provides good RF immunity.

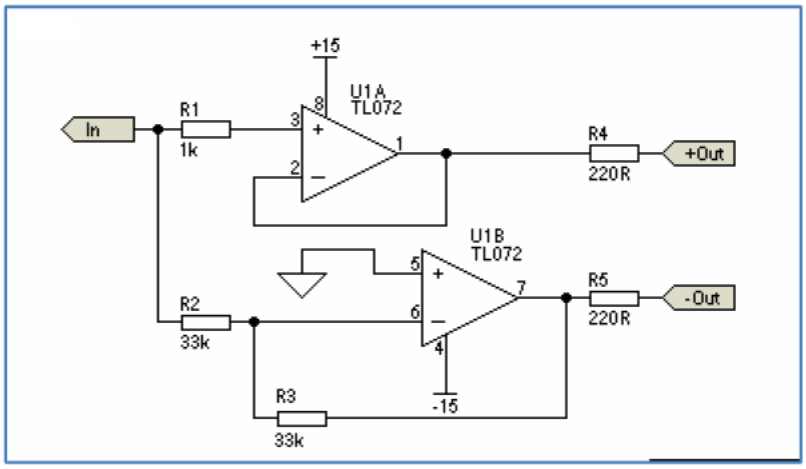
For very low level input signals, such as balanced magnetic microphones, it may be necessary to use an active balanced to unbalanced transformation. This can be accomplished using simple Op-amp circuits such as the one given here.

If higher gain and immunity from induced electrical noise is required then a 3 Op-amp Instrumentation Amplifier may be required. In all cases, RF immunity components should be added.

Output

The module output impedance is nominally 12 KOhm. This means that driving a low impedance balanced line will require buffering before using an unbalanced to balanced transformer.

Alternatively, depending on the grounds within the system, it may be possible to use an unbalanced to balanced Op-Amp circuit.



If using the later solution ensure that extra RF immunity components are added.

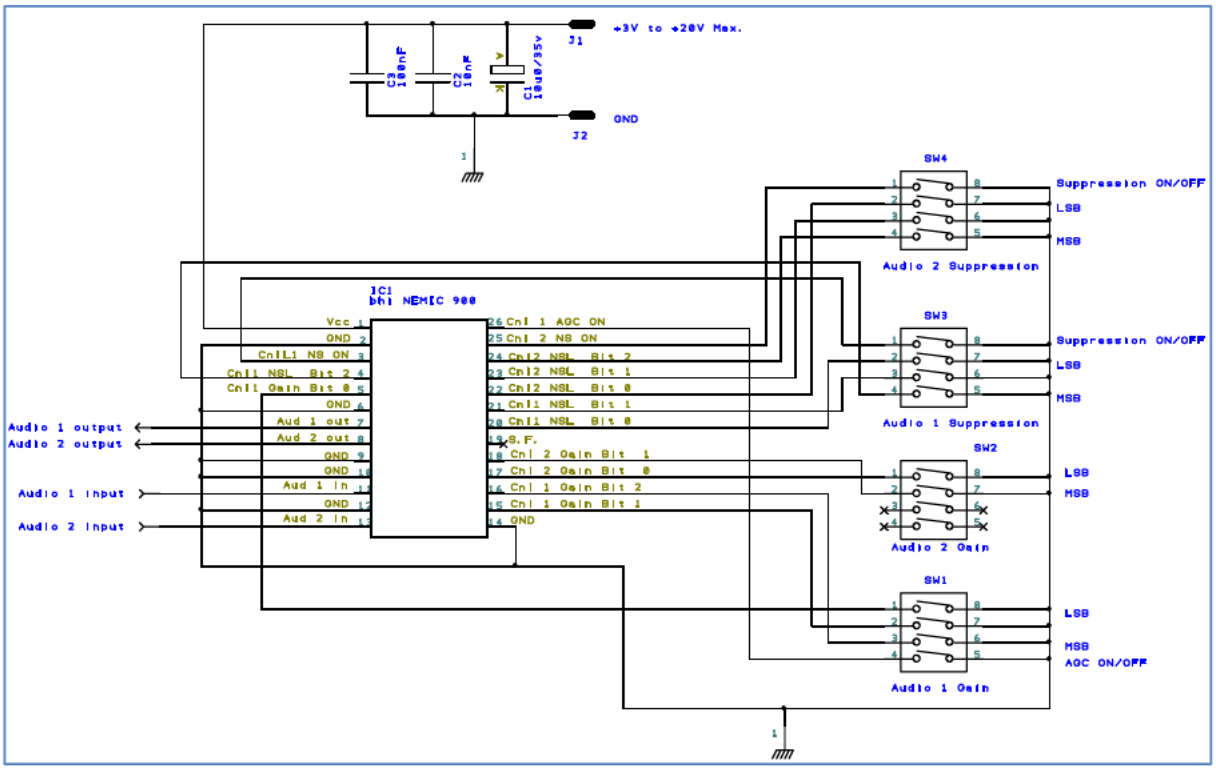
C. Control Lines

The control lines are pulled up internally via several hundreds of kilo-Ohms. If using the module with an active control system (i.e. not using It is important that these lines are not driven beyond 1.8 Volts or below -0.3v negative as the main device will be damaged.

All control GPIO lines should be dressed away from the module and away from any audio input or output lines in order to minimise the likelihood of digital interference to the audio signals.

18. Controlling the device

There are two ways in which the device can be controlled. The module has been designed such that it may be used with purely passive control elements such as switches or solder pads. To get to know the module functionality its worthwhile hooking it up with a set of DIP switches. Using these allow the quick re-configuration of the module functions with the minimum of fuss.



Typical NEDSP900 test circuit

Note: the use of switches allows quick re-configuration of the NEDSP900 for testing. When the switches close the function is selected.

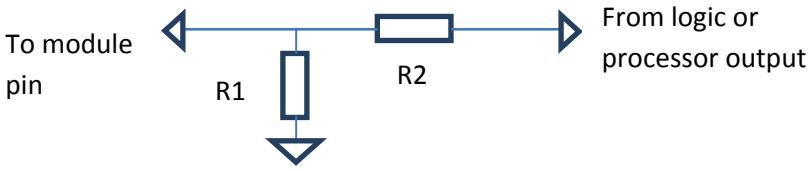
The use of jumper pins or PCB solder patches are recommended for applications where the board is to be integrated into a larger system or where the configuration is likely to be fixed, but may need modifying.

Logic control

There are several ways in which the module may be controlled by external logic or microprocessor. The simplest is to use a transistor to pull the appropriate pin to ground. The collector load and supply is provided by the module itself and all that is required is the appropriate drive to the transistor base. Alternatively, there are logic transistors that will perform this function without the need for any additional resistors.

Many processors may also drive the module directly as they already have full pull up/pull down outputs that use MOSFET's. There are two approaches to this. This simplest is to use a diode placed with it's anode to the module pin and cathode to the processor pin. When the processor pin goes high the diode is back biased and the module pin is allowed to float. When the processor pin goes low the diode conducts and the module pin is pulled low. This is simple and usable where the processor supply is up to 5 Volts. If the processor is powered using 1.8 Volts or lower, the likelihood of the diode being back biased is small and therefore Logic transistors may be the path to take.

The alternative method to using a diode is to use a potential divider network. This will ensure that the module pin is pulled low without a processor being connected. When the processor pulls high, the resistor network needs to be able to divide the processor output down to a maximum of 1.8 Volts.



Processor supply	R1 Ohms	R2 Ohms
3.3v	1K	820R
5v	1K	1.8K

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